

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

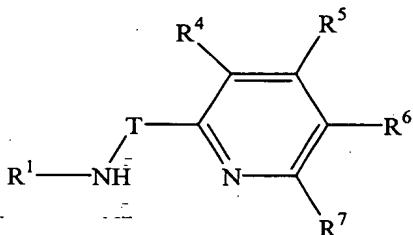
IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

What is claimed is:

1. A process for the polymerization of monomers, said process employing a composition comprising:

(1) a ligand characterized by the following general formula:



wherein R¹ is selected from the group consisting of alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl and combinations thereof.

T is $-CR^2R^3-$ and R² are R³ are independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxyl, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof;

R⁴, R⁵, R⁶ and R⁷ are each independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxyl, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof; and optionally, any combination of R¹, R², R³, R⁴, R⁵, or R⁶ may be joined together in a ring structure;

provided that either R³ or R⁷ is selected only from the group consisting of aryl, substituted aryl, heteroaryl and substituted heteroaryl;

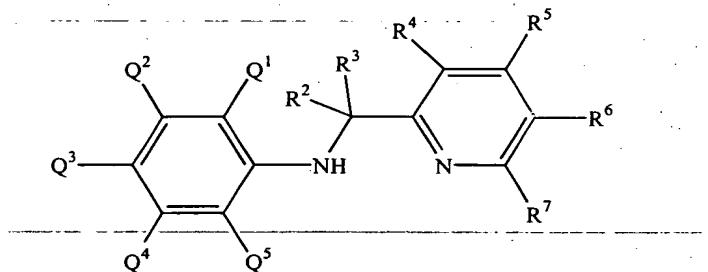
(2) a metal precursor compound characterized by the general formula Hf(L)_n wherein each L is independently selected from the group consisting of halide, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl,

heteroaryl, substituted heteroaryl, alkoxy, aryloxy, hydroxy, boryl, silyl, amino, amine, hydrido, allyl, diene, seleno, phosphino, phosphine, carboxylates, thio, 1,3-dionates, oxalates, carbonates, nitrates, sulphates, ethers, thioethers and combinations thereof or optionally two or more L groups are joined into a ring

5 structure; n is 1, 2, 3, 4, 5, or 6; and

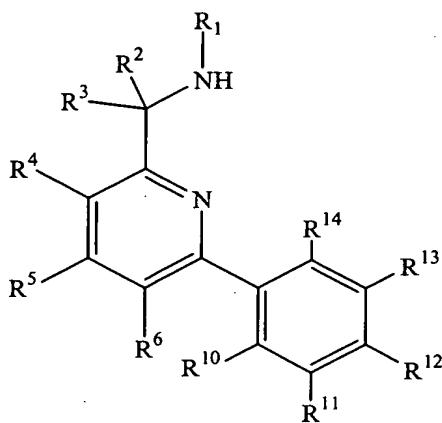
(3) optionally, at least one activator.

2. The process of claim 1, wherein said ligand is characterized by the general formula:



10 such that E is carbon and wherein Q¹, Q², Q³, Q⁴ and Q⁵ are independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, nitro, and combinations thereof; 15 optionally two of Q², Q³ and Q⁴ are joined together in a ring structure.

3. The process of claim 1, wherein said ligand is characterized by the general formula:



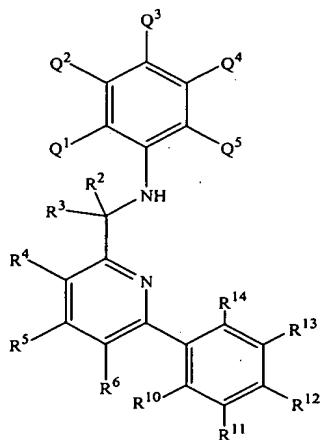
wherein R¹⁰, R¹¹, R¹² and R¹³ are each independently selected from the group consisting of hydrogen, halide, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy,

- 5 aryloxy, silyl, boryl, phosphino, amino, thio, seleno, nitro, and combinations thereof; optionally, two or more R¹⁰, R¹¹, R¹² and R¹³ groups may be joined to form a fused ring system having from 3-50 non-hydrogen atoms; and

R¹⁴ is selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl,

- 10 heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof.

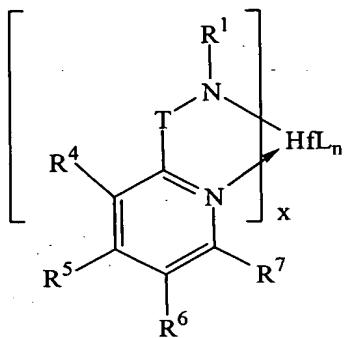
4. The process of claim 3, wherein said ligand is characterized by the formula:



- 15 wherein Q¹, Q², Q³, Q⁴ and Q⁵ are independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, nitro, and combinations thereof; optionally two of Q², Q³ and Q⁴ are joined together in a ring structure.

5. A process for the polymerization of monomers, said process employing

a metal-ligand complex characterized by the following formula:



wherein R¹ is selected from the group consisting of alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl,
5 heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl and combinations thereof.

T is $-CR^2R^3-$ and R² are R³ are independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, 10 aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof;

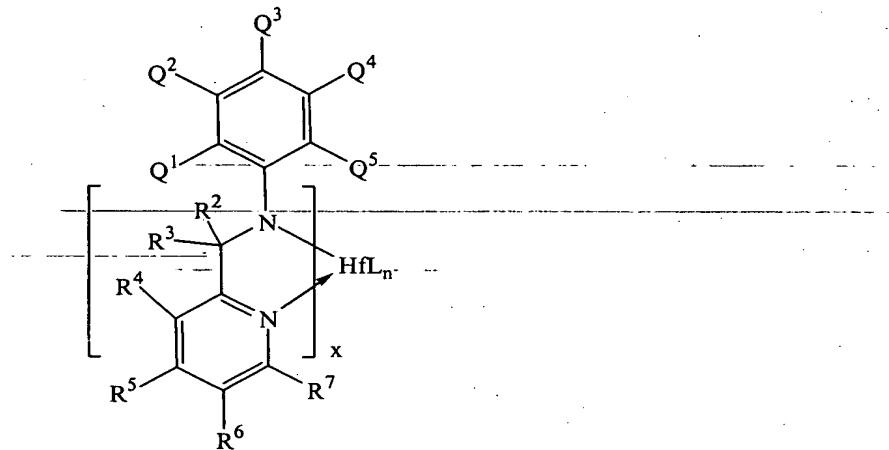
R⁴, R⁵, R⁶ and R⁷ are each independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted 15 aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof; and optionally, any combination of R¹, R², R³, R⁴, R⁵, or R⁶ may be joined together in a ring structure;

provided that either R³ or R⁷ is selected only from the group consisting of aryl, substituted aryl, heteroaryl and substituted heteroaryl;

20 each L is independently selected from the group consisting of halide, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, hydroxy, boryl, silyl, amino, amine, hydrido, allyl, diene, seleno, phosphino, phosphine, carboxylates, thio, 25 1,3-dionates, oxalates, carbonates, nitrates, sulphates, ethers, thioethers and combinations thereof or optionally two or more L groups are joined into a ring

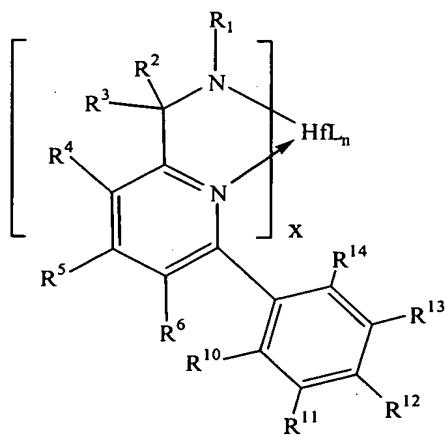
structure; n is 1, 2, 3, 4, 5, or 6; and x is 1 or 2.

6. The process of claim 5, wherein said metal complex is characterized by the formula:



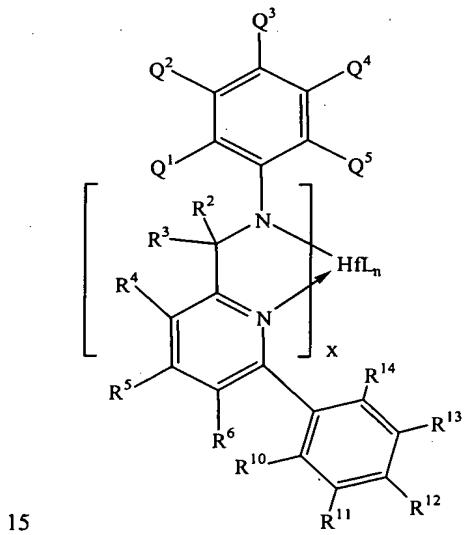
- 5 wherein Q¹, Q², Q³, Q⁴ and Q⁵ are independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, nitro, and combinations thereof; optionally two of Q², Q³ and Q⁴
10 are joined together in a ring structure; and x = 1.

7. The process of claim 5, wherein said complex is characterized by the formula:



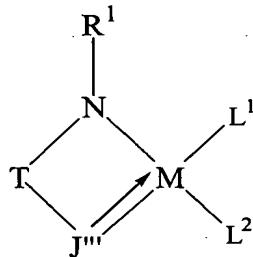
- wherein R¹⁰, R¹¹, R¹² and R¹³ are each independently selected from the group consisting of hydrogen, halide, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, nitro, and combinations thereof; optionally, two or more R¹⁰, R¹¹, R¹² and R¹³ groups may be joined to form a fused ring system having from 3-50 non-hydrogen atoms; and
- R¹⁴ is selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof; and x = 1.
- 10

8. The process of claim 7, wherein said complex is characterized by the general formula:



- wherein Q¹, Q², Q³, Q⁴ and Q⁵ are independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, nitro, and combinations thereof; optionally two of Q², Q³ and Q⁴ are joined together in a ring structure.
- 20

9. A process for the polymerization of monomers, said process employing a metal complex characterized by the formula:



where M is zirconium or hafnium;

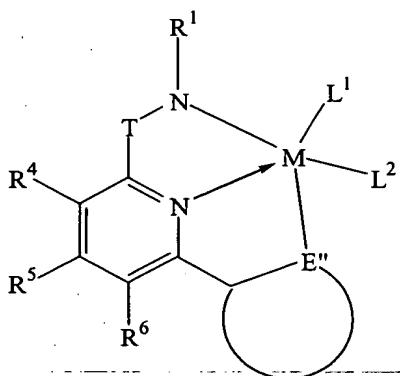
5 wherein R¹ is selected from the group consisting of alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl and combinations thereof.

10 T is a bridging group selected group consisting of $-CR^2R^3-$ and $-SiR^2R^3-$ with R² and R³ being independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof;

15 J''' being selected from the group of substituted heteroaryls with 2 atoms bonded to the metal M, at least one of those 2 atoms being a heteroatom, and with one atom of J''' is bonded to M via a dative bond, the other through a covalent bond; and

20 L¹ and L² are independently selected from the group consisting of halide, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, hydroxy, boryl, silyl, amino, amine, hydrido, allyl, diene, seleno, phosphino, phosphine, carboxylates, thio, 1,3-dionates, oxalates, carbonates, nitrates, sulphates, ethers, thioethers and combinations thereof or optionally two or more L groups are joined into a ring structure.

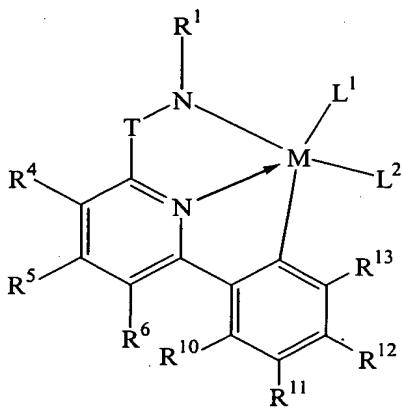
25 10. The process of claim 9, wherein said complex is characterized by the formula:



wherein each of R⁴, R⁵ and R⁶ is independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted 5 aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxyl, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof; and optionally, any combination of R¹, R², R³, R⁴, R⁵, or R⁶ may be joined together in a ring structure; and

10 E'' is either carbon or nitrogen and is part of a cyclic aryl, substituted aryl, heteroaryl, or substituted heteroaryl group.

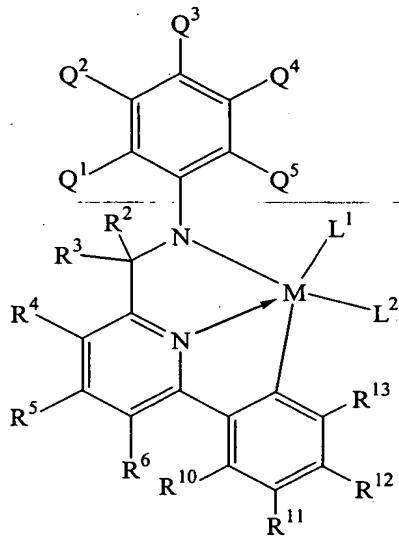
11. The process of claim 10, wherein said complex is characterized by the formula:



wherein R¹⁰, R¹¹, R¹² and R¹³ are each independently selected from the group 15 consisting of hydrogen, halide, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy,

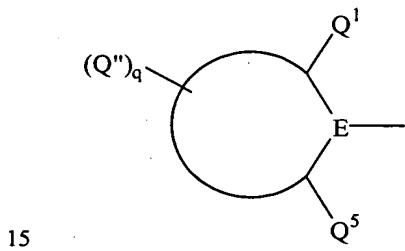
aryloxy, silyl, boryl, phosphino, amino, thio, seleno, nitro, and combinations thereof; optionally, two or more R¹⁰, R¹¹, R¹² and R¹³ groups may be joined to form a fused ring system having from 3-50 non-hydrogen atoms.

12. The process of claim 11, wherein said complex is characterized
5 by the formula:



wherein Q¹, Q², Q³, Q⁴ and Q⁵ are independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, nitro, and combinations thereof; or optionally, two of Q², Q³ and Q⁴ are joined together in a ring structure.

- 10 13. The process of either of claims 1, 3, 5, 7, 9, 10 or 11, wherein
R¹ is characterized by the general formula:



wherein E is either carbon or nitrogen,

Q¹ and Q⁵ are substituents on the R¹ ring at a position ortho to E, with Q¹ and Q⁵ being independently selected from the group consisting of alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, aryl, substituted aryl and silyl, but provided that Q¹ and Q⁵ are not both methyl; and

Q"_q represents additional possible substituents on the ring, with q being 1, 2, 3, 4 or 5 and Q" being selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxyl, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof.

14. The process of either of claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 or 12, wherein said process employs at least one activator.

15. The process of claim 14 wherein said at least one activator comprises an ion forming activator and another reagent selected from the group consisting of a group 13 reagent, a divalent reagent and an alkali metal reagent.

16. The process of either of claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 or 12, wherein said process employs at least one monomer that is an olefin, diolefin or unsaturated compound.

20 17. The process of claim 16, wherein there are at least 2 monomers.

18. The process of claim 17, wherein said at least 2 monomers comprise ethylene and an α -olefin.

19. The process of claim 17, wherein said at least 2 monomers comprise ethylene and either 1-octene or 1-hexene.

25 20. The process of claim 17, wherein there are at least 3 monomers in the process, with said monomers comprising ethylene, an α -olefin and a diolefin.

21. The process of claim 17, wherein said two monomers comprise ethylene and 1-octene.

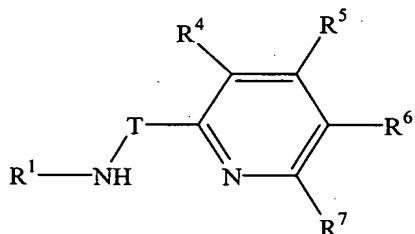
22. The process of claim 21, wherein R³ is either aryl or substituted aryl.

5 23. The process of claim 21, wherein R¹ is selected from the group consisting of mesityl; 2-Me-naphthyl; 2,6-(Pr)₂-C₆H₃-; 2-Pr-6-Me-C₆H₃-; 2,6-Et₂-C₆H₃-; and 2-sec-butyl-6-Et-C₆H₃-.

10 24. The process of claim 21, wherein, when present, R⁷ is selected from the group consisting of phenyl, napthyl, mesityl, anthracenyl and phenanthrenyl.

25. A catalyst for the production of a polymer comprising a composition comprising:

(1) a ligand characterized by the following general formula:



15 wherein R¹ is selected from the group consisting of alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl and combinations thereof.

T is -CR²R³- and R² are R³ are independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof;

20 R⁴, R⁵, R⁶ and R⁷ are each independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl,

25 hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl,

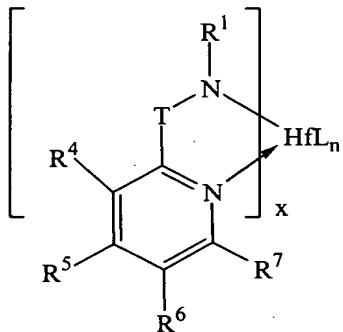
substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof; and optionally, any combination of R¹, R², R³, R⁴, R⁵, or R⁶ may be joined together in a ring structure;

5 provided that either R³ or R⁷ is selected only from the group consisting of aryl, substituted aryl, heteroaryl and substituted heteroaryl;

(2) a metal precursor compound characterized by the general formula Hf(L)_n wherein each L is independently selected from the group consisting of halide, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl-heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, hydroxy, boryl, silyl, amino, amine, hydrido, allyl, diene, seleno, phosphino, phosphine, carboxylates, thio, 1,3-dionates, oxalates, carbonates, nitrates, sulphates, ethers, thioethers and combinations thereof or optionally two or more L groups are joined into a ring structure; n is 1, 2, 3, 4, 5, or 6; and

10 15 (3) optionally, at least one activator.

26. A catalyst for the production of a polymer comprising at least one activator and a metal-ligand complex characterized by the following formula:



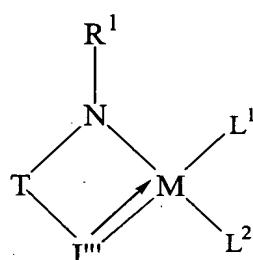
20 wherein R¹ is selected from the group consisting of alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl and combinations thereof.

T is -CR²R³- and R² and R³ are independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl,

heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof;

- R⁴, R⁵, R⁶ and R⁷ are each independently selected from the group consisting of
5 hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof; and optionally, any combination of R¹, R², R³, R⁴, R⁵, or R⁶ may be joined together in a ring structure;
10 provided that either R³ or R⁷ is selected only from the group consisting of aryl, substituted aryl, heteroaryl and substituted heteroaryl; each L is independently selected from the group consisting of halide, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, 15 heteroaryl, substituted heteroaryl, alkoxy, aryloxy, hydroxy, boryl, silyl, amino, amine, hydrido, allyl, diene, seleno, phosphino, phosphine, carboxylates, thio, 1,3-dionates, oxalates, carbonates, nitrates, sulphates, ethers, thioethers and combinations thereof or optionally two or more L groups are joined into a ring structure; n is 1, 2, 3, 4, 5, or 6; and x is 1 or 2.

- 20 27. A catalyst for the production of a polymer comprising at least one activator and a metal complex characterized by the formula:



where M is zirconium or hafnium;

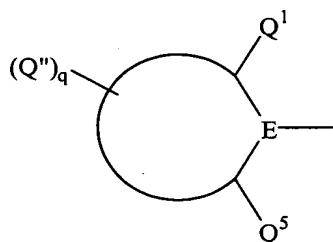
- wherein R¹ is selected from the group consisting of alkyl, substituted alkyl, 25 cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl and combinations thereof.

~~T~~ is a bridging group selected group consisting of $-CR^2R^3-$ and $-SiR^2R^3-$ with R^2 and R^3 being independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof;

~~J'''~~ being selected from the group of substituted heteroaryls with 2 atoms bonded to the metal M, at least one of those 2 atoms being a heteroatom, and with one atom of J''' is bonded to M via a dative bond, the other through a covalent bond; and

~~10 L¹ and L² are independently selected from the group consisting of halide, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl, heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxy, hydroxy, boryl, silyl, amino, amine, hydrido, allyl, diene, seleno, phosphino, phosphine, carboxylates, thio, 1,3-dionates, oxalates, carbonates, nitrates, sulphates, ethers, thioethers and combinations thereof or optionally two or more L groups are joined into a ring structure.~~

28. The catalyst of either of claims 25, 26 or 27, wherein R¹ is characterized by the general formula:



~~20 wherein E is either carbon or nitrogen,~~

~~Q¹ and Q⁵ are substituents on the R¹ ring at a position ortho to E, with Q¹ and Q⁵ are independently selected from the group consisting of alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, aryl, substituted aryl and silyl, but provided that Q¹ and Q⁵ are not both methyl; and~~

~~25 Q''_q represents additional possible substituents on the ring, with q being 1, 2, 3, 4 or 5 and Q'' being selected from the group consisting of hydrogen, alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heteroalkyl, substituted heteroalkyl,~~

heterocycloalkyl, substituted heterocycloalkyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkoxy, aryloxyl, silyl, boryl, phosphino, amino, thio, seleno, halide, nitro, and combinations thereof.

29. The catalyst of either of claims 25, 26 or 27, wherein R³ is selected from the group consisting of benzyl, phenyl, naphthyl, 2-biphenyl, 2-dimethylaminophenyl, 2-methoxyphenyl, anthracenyl, mesityl, 2-pyridyl, 3,5-dimethylphenyl, o-tolyl, and phenanthrenyl.

30. The catalyst of either of claim 28, wherein Q¹ and Q⁵ are, independently, selected from the group consisting of -CH₂R¹⁵, -CHR¹⁶R¹⁷ and methyl, provided that not both Q¹ and Q⁵ are methyl, wherein R¹⁵ is selected from the group consisting of alkyl, substituted alkyl, aryl and substituted aryl; R¹⁶ and R¹⁷ are independently selected from the group consisting of alkyl, substituted alkyl, aryl and substituted aryl; and optionally R¹⁶ and R¹⁷ are joined together in a ring structure having from 3-50 non-hydrogen atoms.

31. The catalyst of claim 29, wherein Q², Q³, and Q⁴ are each hydrogen and Q¹ and Q⁵ are both isopropyl; or both ethyl; or both sec-butyl; or Q¹ is methyl and Q⁵ is isopropyl; or Q¹ is ethyl and Q⁵ is sec-butyl.

32. The catalyst of claim 28, wherein R¹ is selected from the group consisting of mesityl; 2-Me-naphthyl; 2,6-(Pr)₂-C₆H₃-; 2-Pr-6-Me-C₆H₃-; 2,6-Et₂-C₆H₃-; and 2-sec-butyl-6-Et-C₆H₃-.

33. The catalyst of either of claims 25, 26 or 27, wherein R⁷ is selected from the group consisting of phenyl, naphthyl, mesityl, anthracenyl and phenanthrenyl.

